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MULTILATERALS

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Evolution simplifies multilateral wells

Recent engineering strategy has embraced the concept of simple, yet highly functional, multilateral completions.

AUTHOR

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In an effort to make multilaterals more acceptable from a risk standpoint, multilateral completion systems that are simpler and less risky to install are being developed. Despite the six basic levels of multilateral categorizations (Table 1), most applications can be categorized into two simple groups: wells that require pressure integrity at the junction, and wells that do not. To provide maximum functionality for both groups, focus has been placed on developing Level 3 and Level 6 multilateral systems that address a variety of multilateral well applications.

Level 3 technology progression

The early well completions categorized as Level 3 multilaterals were constructed using a flow-through guidestock and slotted liner or screen in the lateral, which was anchored back to the mainbore by a liner hanger packer. Flow was allowed through the flow-through guidestock from the mainbore completion, where it commingled with the lateral production via perforations or slots in the lateral liner overlap in the mainbore. The challenge was to provide a means for allowing mainbore re-entry. With this increased functionality, Level 3 could be a viable, simple replacement for Level 4 multilaterals as well as level 1 and 2 completions.

With a focus on simplicity, design iterations led to the development of the Hook Hanger system. The intent was to construct a mechanically basic (no moving parts) and easy-to-install tool. The Hook Hanger is a liner with a machined window for mainbore re-entry. A hook at the bottom of the machined window is used to hang the Hook Hanger at the bottom of the casing exit window. Holddown slips at the top of the hook hanger ensure the Hook Hanger is engaged to the mainbore casing. Re-entry is achieved using a mainbore or lateral diverter, which orients in the hook hanger at the junction, to deflect coiled tubing or coupled pipe into the desired wellbore. With the Hook Hanger design, Level 3 multilaterals have full re-entry functionality into the mainbore and lateral completions.

Application simplicity

Thirty-five Hook Hanger junctions have been completed in Venezuela's Orinoco heavy oil belt (Figure 1). These installations began with a standard horizontal open-hole well with a slotted liner anchored to the mainbore casing.

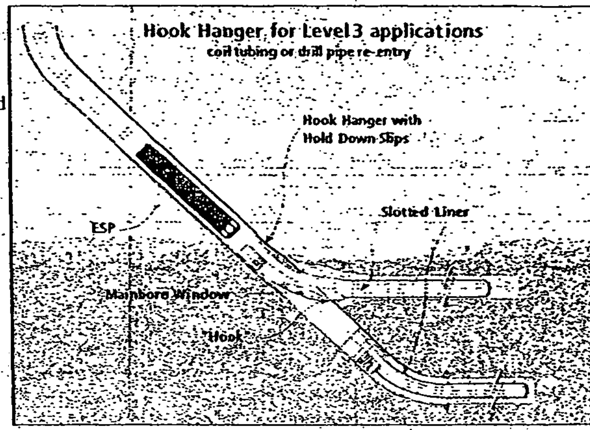

Figure 1. The basic Hook Hanger design used in the Venezuela wells.

In the essence of simplicity, the Hook Hanger junction equipment was run as a part of the slotted liner completion. The typical bottomhole assemblies consist of (from bottom to top) a bent joint, float shoe, slotted pipe, casing swivel and the Hook Hanger body with holddowns.

In these Venezuelan heavy oil applications, re-entry was essential for future stimulation and cleanout runs in the lateral and mainbore completions. For mainbore re-entry, a mainbore diverter was conveyed on drill pipe using a hydraulic running tool. The diverter's nose was sized larger than the mainbore window of the Hook Hanger so the tool would remain inside the Hook Hanger body.

TABLE 1. TECHNOLOGY ADVANCEMENT FOR MULTILATERALS (TAML) LEVELS

● Level 1	Open/unsupported junction.
● Level 2	Mother bore cased and cemented, lateral bore open.
● Level 3	Mainbore cased and cemented, lateral bore cased but not cemented.
● Level 4	Mainbore and lateral bore cased and cemented.
● Level 5	Pressure integrity at the junction achieved with completion equipment. (Cement is not acceptable.)
● Level 6	Pressure integrity at the junction achieved with casing. (Cement is not acceptable).
● Level 6S	Downhole Splitter, large main wellbore with two smaller bores.

An orientation profile on the diverter mated with a lug internal to the Hook Hanger as the diverter was run inside. This profile aligned the diverter scoop face with the mainbore window. A simple collet mechanism snapped into a profile inside the Hook Hanger, locking the diverter in place. The hydraulic running tool was released and retrieved from the well. Re-entry assemblies will now be deflected off the mainbore diverter scoop face, such that all assemblies are passed out the Hook Hanger mainbore window into the mainbore completion. To retrieve the mainbore diverter, the hydraulic running tool, conveyed on drill pipe, engaged the mainbore diverter, and straight over-pull releases the collet from the profile.

For lateral re-entry, a lateral diverter is conveyed on drill pipe using the same hydraulic running tool for the mainbore diverter. The diverter is sized so that it will not pass through the mainbore window, remaining inside the Hook Hanger body where it no-gos on the lug with the collet mechanism simultaneously snapping into the profile. The lateral diverter is simply a tube run inside the Hook Hanger, which straddles the mainbore window. All re-entry assemblies must pass inside this tube and out into the lateral completion. Again, this diverter is retrieved using the same hydraulic running tool.

The Hook Hanger has greatly simplified the junction construction process while creating a Level 3 multilateral well with

full re-entry capability into either the mainbore or lateral completion. The success of these Venezuelan wells has spurred further development of Level 3 technology with implementation planned throughout 2000. These next-generation designs have increased the functionality of the Hook Hanger with stackable versions allowing the creation of trilateral wells with selective re-entry, large-bore versions allowing electric submersible pump installations below the junction, and flanged versions that provide mechanical sand exclusion at the junction.

Level 6 solutions

Level 6 technology uniquely embraces simplicity while providing optimal functionality. Level 6 multilaterals deliver pressure integrity at the junction using the casing. This eliminates the need for extensive completion equipment to create pressure integrity by straddling the casing exit window with isolation packer assemblies. Less equipment equals less risky multilateral applications.

At least one company makes Level 6 systems with premanufactured junctions. These premanufactured systems include the Formation Junction and the DeepSet Splitter. The Formation Junction system is deployed with standard casing programs and hole sizes using reformable technology to return a preformed leg to full gauge downhole. The DeepSet Splitter is run in a larger hole with two full-gauge lateral legs that extend from the splitter assembly. The DeepSet Splitter is the newest premanufactured junction deployed to create Level 6 multilaterals.

Splitter applications

Recently, a major operating company in Nigeria determined multilaterals would be the most effective means of developing reserves. Since pressure integrity at the junction was desired with dual-string production to the surface, level 5 and 6 multilateral systems were evaluated using quantitative risk analysis to determine the junction completion method with the least amount of risk. The results revealed that the 13⅜in. top connection DeepSet Splitter with two 7⅝in. legs was the clear choice for ease of installation. The operator emphasized that a simple, low-risk multilateral creation method must be implemented in the first evaluation wells, since the outcome would determine the fate of future field development. All parties involved conceded the DeepSet Splitter system yielded the highest probability of success.

For the Nigerian evaluation wells, the installation process began with drilling out of 18⅝in. casing with a 17½in. open hole to the desired junction-setting depth, then opening the hole to 20in. The 13⅜in. by 7⅝in. by 7⅝in. DeepSet Splitter was conveyed on 13⅜in. casing with standard float equipment integral to one of the 7⅝in. legs (leg No. 1). Orientation was determined by running an anchor, circulation sub and MWD that mated to a lug inside the DeepSet Splitter. Readings were obtained, and the 13⅜in. casing was rotated as needed.

A 7⅝in. drilling riser with a riser diverter was run inside the 13⅜in. casing. The riser diverter mated on the DeepSet Splitter lug and self-oriented the drilling riser to leg No. 1. The drilling riser was needed to provide a conduit for containing cement and debris (avoiding contamination of the DeepSet Splitter), as well as ensure effective cuttings transport to surface when drilling out the lateral legs. Once the drilling riser was landed, rotation of the riser locked the riser diverter to the DeepSet Splitter. The 7⅝in. drilling riser then was energized by pulling tension and setting a riser tension hanger inside the 13⅜in. casing. Energizing the riser

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Steven S. Bell, Engineering Editor

Multilateral system with full re-entry access installed

Norsk Hydro recently installed the world's first multilateral system with full-bore re-entry access on it's Norwegian North Sea Oseberg C platform. The well has two laterals about 5,000-ft long out of a 10,000 ft main wellbore and includes full lateral liner connectivity and a hydraulically isolated lateral junction.

Multilateral technology was identified by the operator as a means to increase recoverable reserves from the mature field. The capability to commingle production from primary and secondary formations is required for this operation. Due to pressure differentials, each formation will need to be isolated periodically. Also, the secondary formation will likely require reperforation, so selective re-entry to the main and secondary wellbores for running perforating guns and production logging equipment and installing production control devices is a necessity.

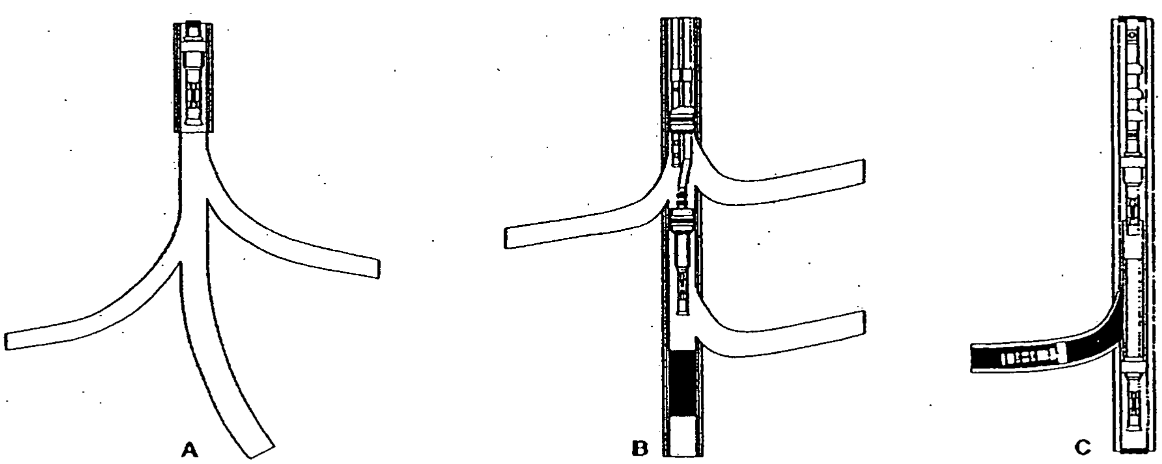
The multilateral system was developed by Halliburton, working closely with Weatherford Enterra. The system on the Norsk Hydro dual lateral well uses 9⅝-in. casing with a 7-in. full-bore steel liner connected mechanically and isolated at the junction. A 7-in. production tubing string enables maximum flow in a monobore configuration. A similar job was recently completed in the Arabian Gulf.

Norsk Hydro estimates that, by the year 2000, they will use this multilateral technology to drill at least 40 wells on prospects currently identified in the Norwegian Sea. The company is currently using the system for re-entering an existing wellbore, also on Oseberg C.

Chevron eliminates casing string. An ambitious proposal to management from the drilling and petroleum engineering teams is saving Chevron nearly $1 million per well on its UK North Sea Britannia field project by eliminating an entire casing string from each design. This also has put drill teams of the *Sovereign Explorer* and *Sedco 711* 11% ahead of schedule, contributing to further cost savings.

Original casing designs included a 13⅜-in. casing string to be set at 7,500 ft MD in each well. Experience in the field, good wellbore integrity—due in part to a low-toxicity oil-based mud—and faster-than-expected drilling with motors has negated the need for this string. On the subsequent M4 well, the 12¼-in. hole section was drilled at 45° from 2,500-ft MD, through the Eocene and Paleocene sands and upper Cretaceous chalk, to 15,700-ft MD, leaving 13,200 ft of open hole. On the following well (just recently completed), this extended hole section was drilled 14,122 ft at 55°. By eliminating the 13⅜-in. string, Chevron has saved about $960,000 per well. At least two, possibly three, more wells will be drilled in this fashion. wo

Evolution of multilateral technology



a) Multiple openhole scenario mostly associated with work in the Austin Chalk (Texas) and Middle East. Here, formations are competent and do not require casing to maintain wellbore stability. This situation offers no access and no isolation capability. b) Openhole laterals cut out of existing casing using whipstocks and mills. Prepacked screens or slotted liners can be run in laterals but not tied back to the main wellbore. Some isolation capabilities exist to open and close flow. c) Cased wellbore, with full-bore lateral liner. The latest phase of multilateral technology offers connectivity, isolation capability and full-bore re-entry access.

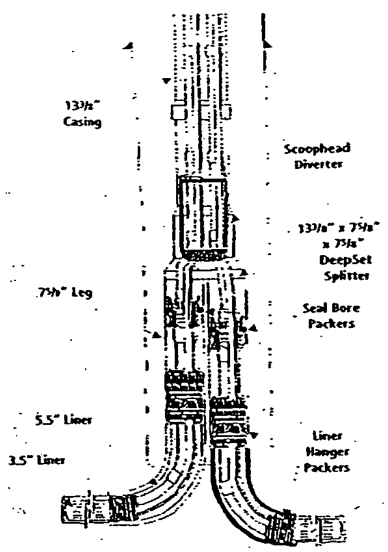


Figure 2. The final completion design for the Nigeria wells

was needed to prevent fatigue failure of the connections during drilling operations.

The cementing string then was run inside the 7⅝in. drilling riser where a slick stinger landed in the packoff bushing in leg No. 1. At this stage, the Deepset Splitter and 13⅜in. casing were ready to be cemented in place. Following cementing procedures, leg No. 1 was drilled out, and a 7in. ream while drilling (RWD) hole was created to the desired liner setting depth. A 5½in. liner with float equipment was run inside the 7⅝in. drilling riser and out into the 7in. open hole interval. The liner was cemented in place and hung off in leg No. 1 using conventional methods.

A drilling assembly then was run inside the 7⅝in. drilling riser and 5½in. intermediate liner where a 5in. RWD open hole was drilled into the reservoir. Then, 3½in. slotted liner was run out into the reservoir and hung back into the 5½in. intermediate liner. A production packer was set in leg No. 1 of the DeepSet Splitter as a future 3½in. tubing tieback receptacle along with a 3½in. plug to isolate leg No. 1 during the leg No. 2 creation process. Leg No. 1 is complete.

Removal of the drilling riser was achieved by engaging the riser tension hanger, unsetting the hanger and releasing the riser diverter. The drilling riser and riser diverter were pulled from the well. Once on the surface, the riser diverter orientation was changed to automatically align the drilling riser to leg No. 2. Completion of the second leg mirrors the procedures outlined for leg No. 1.

The final completion simply involved running 3½in. dual-string tubulars with a scoophead diverter attached, which oriented on the DeepSet Splitter lug allowing one string to sting into a production packer. The second tubing string scopes through the scoophead diverter thereby landing the tubing into the other production packer. Figure 2 shows the final wellbore configuration.

Two DeepSet Splitter multilateral wells have been completed in Nigeria with unparalleled success. No downtime was associated with the multilateral operations, and contingencies were not used during deployment. According to the operator, the success of these wells can be attributed to the simplicity of DeepSet Splitter design and ease of installation. Using multilateral technology, two independent well applications have yielded US $2 million in savings in the form of mobilization and demobilization, mud and wellhead costs. ■

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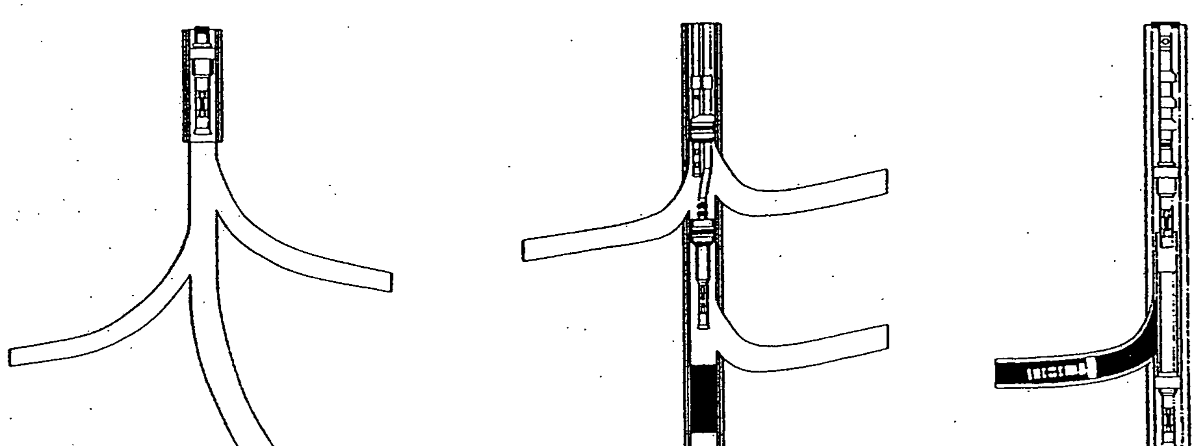

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